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DIRECT TESTIMONY OF
ROBERT B. WHORTON, P.E.

ON BEHALF OF
SOUTH CAROLINA ELECTRIC & GAS COMPANY
DOCKET NO. 2008-196-E

Q. PLEASE STATE YOUR NAME AND BUSINESS ADDRESS.

A. My name is Robert B. Whorton. My business address is South Carolina Electric & Gas Company (SCE&G), P.O. Box 88, Jenkinsville, South Carolina, 29065.

Q. BY WHOM ARE YOU EMPLOYED AND IN WHAT CAPACITY?

A. I am employed by SCE&G as a Senior Engineer.

Q. PLEASE BRIEFLY DESCRIBE YOUR EDUCATIONAL BACKGROUND, PROFESSIONAL ASSOCIATIONS, AND EXPERIENCE.

A. I received my bachelor's degree in engineering, majoring in civil/structural engineering, from the University of South Carolina in 1970. I obtained my South Carolina Professional Engineer Registration (SC #06157) in 1976, which has been maintained current to date. I have been a member of the Earthquake Engineering Research Institute (EERI) since

1 1981 and have participated in several national earthquake conferences
2 during the last 25 years.

3 I was initially employed by SCE&G in April 1971 as a Junior
4 Engineer in the Nuclear Engineering Design Department for the Virgil C.
5 Summer Nuclear Station (VCSNS), and have continuously worked on the
6 nuclear project since that time supporting all phases of design, licensing,
7 construction, and operation.

8 During the initial construction and excavation for VCSNS Unit 1 in
9 the early 1970s, I was assigned as engineering lead for all aspects of the
10 geotechnical, geological, and seismological investigations and evaluations,
11 including the licensing and application interfaces. From 1973 to 1974, I
12 coordinated an extensive evaluation of the geological conditions within the
13 Unit 1 foundation, which involved interface and supervision with a team of
14 prominent geology and seismology professors from five (5) southeastern
15 universities.

16 From 1977 to 1983, I coordinated all seismological investigations
17 for the VCSNS site related to adequacy of the seismic design. The
18 coordination of these extensive seismological evaluations and studies
19 involved interface with renowned geology, seismology, geophysics, and
20 earthquake engineering experts from industry and academia. Results of
21 these studies were presented and discussed with the U.S. Nuclear
22 Regulatory Commission (NRC), and extensively reviewed as part of the

1 NRC Advisory Committee on Reactor Safeguards (ACRS) and Atomic
2 Safety and Licensing Board (ASLB) meetings and hearings associated with
3 the Unit 1 operating license.

4 During the mid to late 1980s, I participated with industry and the
5 Electric Power Research Institute (EPRI) as part of the Seismicity Owners
6 Group (SOG) for resolution of uncertainties in occurrences of large
7 earthquakes. This process led to the creation of the EPRI Probabilistic
8 Seismic Hazard Analysis (PSHA) methodology which is now being used to
9 develop the seismic hazard design levels for the new plants around the
10 United States.

11 Also during the late 1980s, I participated with industry
12 representatives and EPRI in the development of new criteria for assessment
13 of the significance of earthquakes on operating nuclear plants, including the
14 need for plant shutdown subsequent to the occurrence of an earthquake
15 which exceeds the design level of a plant's Operating Basis Earthquake
16 (OBE) standard. These efforts were extensively reviewed and accepted by
17 the NRC and are now included as part of their regulatory guidance.

18 From 1992 to 1995, I coordinated an extensive seismic design
19 evaluation for Unit 1 as required by NRC Generic Letter 88-20,
20 Supplement 4, *Individual Plant Examination for External Events*. This
21 evaluation effectively required each operating plant to evaluate an
22 earthquake approximately two times the current design level to look for

1 vulnerabilities. All safety-related plant structures and almost 1,000 plant
2 safe shutdown components were evaluated under an approved Seismic
3 Margin Assessment methodology as developed by industry and EPRI. This
4 effort involved specific, extensive plant evaluations by SCE&G personnel
5 and industry earthquake engineering experts.

6 In 1994, I was a presenter on seismic design and instrumentation for
7 U.S. nuclear plant sites at an International Atomic Energy Agency (IAEA)
8 conference in Vienna, Austria.

9 In 1996 and 1997, I was selected by the IAEA to participate on three
10 (3) separate team missions (visits) to the Armenia Nuclear Power Plant to
11 provide guidance on seismic design requirements and seismic
12 instrumentation needed to support continuation of plant operations.

13 From 1999 to 2004, I was the structural lead for development of the
14 Unit 1 plant license renewal project, which involved numerous interactions
15 with NRC and the ACRS.

16 Beginning in 2005, I participated in the initial siting, geotechnical,
17 and geological studies for the currently proposed VCSNS Units 2 and 3. I
18 subsequently coordinated and assisted our industry consultants in the
19 geological, geotechnical, and seismological investigations which were
20 developed as part of the Combined Operating License (COL) Application.
21 This effort also involved coordination of a renowned team of seismology
22 and earthquake engineers, assembled as a Seismic Technical Advisory

1 Committee, with the oversight function to ensure conformance with
2 industry regulations and accepted industry practices.

3 In 2006, I formed and chaired the AP1000 Seismic Working Group
4 (APSWG) to ensure consistency in development of COL applications from
5 nearby utilities (Southern Company, Duke Energy, Progress Energy, and
6 TVA) related to the seismic design of the AP1000 plants. For the past two
7 years the APSWG has worked closely with the NRC, EPRI, industry
8 experts and the Nuclear Energy Institute (NEI) for resolution of generic
9 industry issues related to seismic design.

10

11 **Q. WHAT IS THE PURPOSE OF YOUR TESTIMONY?**

12 A. The purpose of my testimony is to discuss the geological,
13 geotechnical, and seismological characteristics related to the construction
14 and operation of two additional nuclear power plants to be located at the
15 existing Virgil C. Summer Nuclear Station site (VCSNS Site or Site) near
16 Jenkinsville in Fairfield County, South Carolina (Facility).

17

18 **Q. WHAT IS THE FACILITY?**

19 A. Two nuclear power plants, Units 2 and 3 (Facility), will be
20 constructed and co-located with an operating nuclear power plant, Unit 1, at
21 SCE&G's Virgil C. Summer Nuclear Station near Jenkinsville.

22

1 **Q. WHAT IS YOUR ROLE REGARDING THE PROPOSED**
2 **FACILITY?**

3 A. I am the SCE&G project lead for coordination, oversight, and
4 resolution of all issues associated with site investigations and evaluations
5 related to geology, geotechnical, seismology, and seismic design.

6

7 **Q. ARE THERE ANY DOCUMENTS OR MATERIALS THAT**
8 **SUPPORT OR ILLUSTRATE YOUR EXPERT TESTIMONY**
9 **REGARDING THE GEOLOGICAL AND SEISMOLOGICAL**
10 **ATTRIBUTES OF THE SITE AND THEIR RELATIONSHIP TO**
11 **UNITS 2 AND 3?**

12 A. Yes. In support of SCE&G's combined license application to the
13 U.S. Nuclear Regulatory Commission, an Environmental Report (ER) was
14 prepared by consultants retained by SCE&G and functioning under
15 SCE&G's supervision. The ER was submitted by SCE&G as a required
16 part of the NRC Combined Operating License Application (COLA). The
17 ER provides a thorough review of the foreseeable environmental impacts
18 from the construction and operation of the Facility and includes a section
19 related to the geological and seismological conditions at the Site, namely,
20 Section 2.6, with which I am very familiar and knowledgeable.

21 In addition to the ER, a Final Safety Analysis Report (FSAR) was
22 prepared and submitted to NRC. The FSAR contains a detailed and

1 comprehensive review of the geological, geotechnical, and seismological
2 conditions at the Site. I am very familiar with and knowledgeable about the
3 FSAR, which is attached to my testimony as **Exhibit No. ____ (RBW-1)**.
4

5 **Q. PLEASE SUMMARIZE THE GEOLOGICAL CHARACTERISTICS**
6 **OF THE SITE LOCATION.**

7 A. The VCSNS Site is located in the Piedmont province of central
8 South Carolina, bounded on the southeast by the Coastal Plain province and
9 on the northwest by the Blue Ridge province, as shown in Figure 2.5.1-201
10 of the FSAR, a copy of which is included on the next page of this
11 testimony. A geologic province is an area defined by common rock
12 structures and formations.

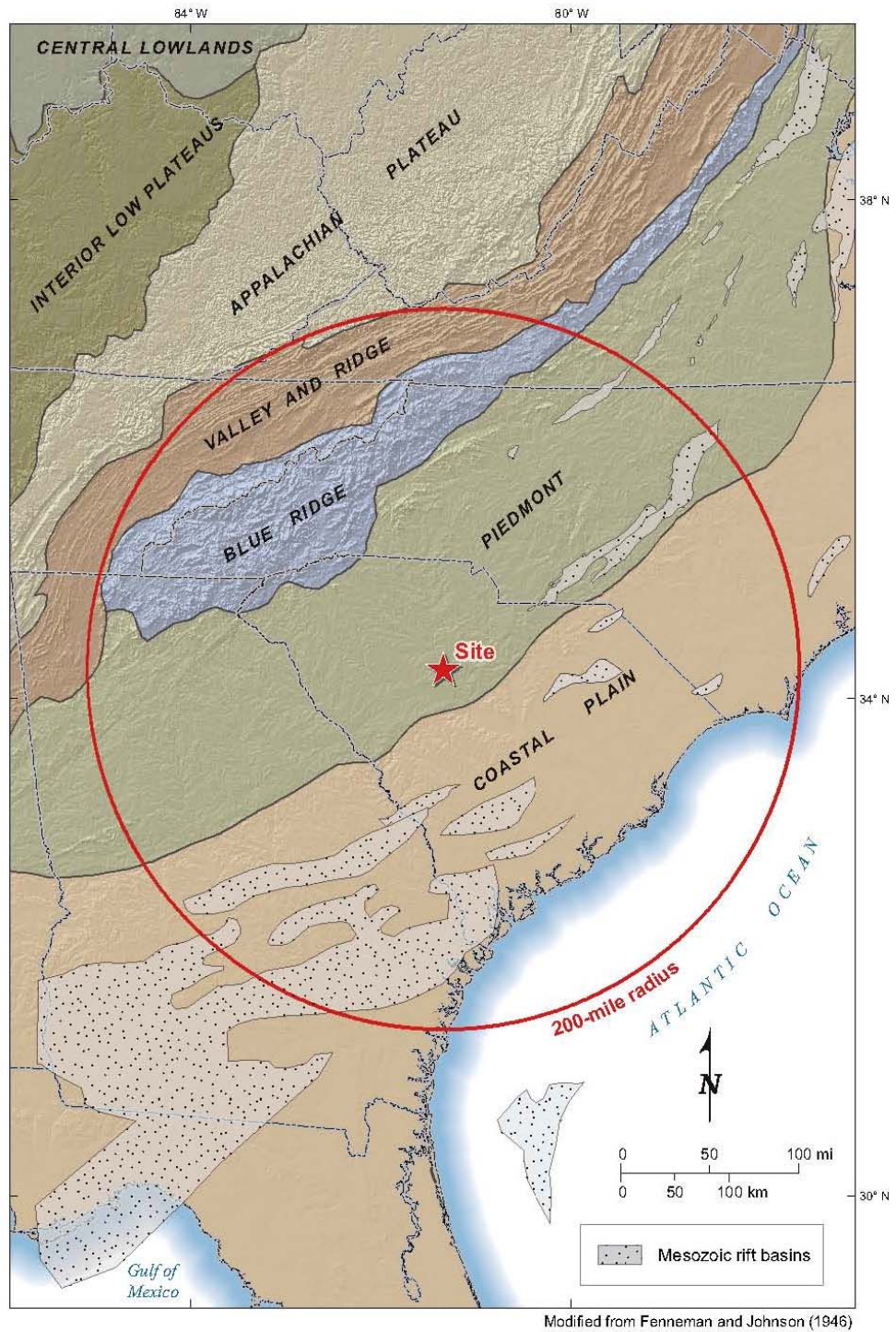
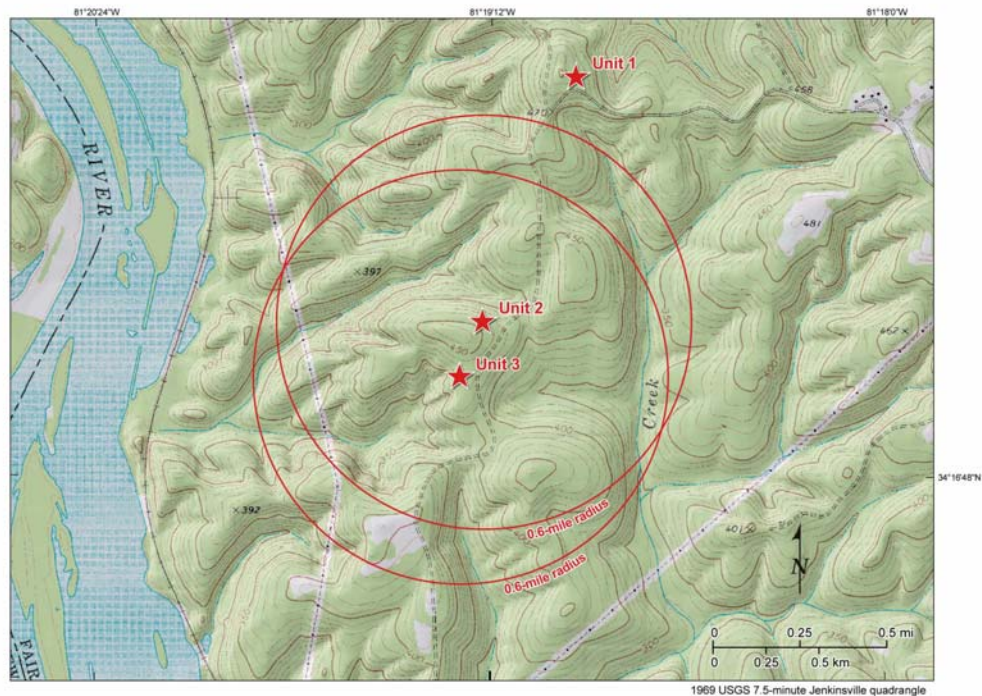


Figure 2.5.1-201. Map of Physiographic Provinces and Mesozoic Rift Basins

1 The site lies approximately 3 miles northwest of Jenkinsville, South
2 Carolina, and about 1 mile east of the Broad River.

3 The site topography is characteristic of the region, consisting of
4 gently to moderately rolling hills and generally well-drained mature
5 valleys, as seen in the site topographic map.



6 **Figure 2.5.1-222. Site Topographic Map**

7 All local streams drain into the Broad River. The local drainage pattern is
8 generally dendritic; however, a subtle trellis pattern is also evident and
9 probably a result of regional bedrock structure and joint systems.

10 Most of the local terrain is mantled by residual soils and saprolite (or
11 chemically weathered rock) that overlies igneous and metamorphic bedrock
12 at depth, typically of granitic origin. Relatively few natural bedrock

1 outcrops are present within the site area, which is characteristic of the long
2 weathering history and deep residual soil development of the Piedmont.
3 The original undisturbed soils (residual) near the ground surface at the site
4 typically consist of red to reddish-brown stiff clayey and silty soils with
5 varying sand content. With depth, the soils become more yellow to
6 reddish-brown micaceous sandy silt and/or silty sand, and are commonly
7 referred to as saprolite.

8 Under the NRC design criteria, faults are classified as “not capable”
9 if the faults have not had any movement at or near the ground surface
10 within the last 35,000 years or any recurring movement within the past
11 500,000 years. Faults in the general vicinity of the Facility fall within the
12 “not capable” classification, rendering the site location a safe site under the
13 applicable NRC standard for this category.

14

15 **Q. THE SITE LOCATION HAS AN OPERATING NUCLEAR PLANT.**
16 **HOW DO THE GEOLOGICAL AND SEISMOLOGICAL**
17 **CHARACTERISTICS OF UNIT 1 RELATE TO THE DESIGN**
18 **REQUIREMENTS FOR UNITS 2 AND 3?**

19 A. Since Unit 1 is approximately 1 mile northeast of the proposed site
20 for Units 2 and 3, the local and regional geological and seismological
21 characteristics are comparable. Most of the Unit 1 power block structures
22 are founded on bedrock, which will also be the case for the nuclear island

1 foundation for the new plants. As described in SCE&G witness Steve
2 Byrne's testimony, the nuclear island is the location of the containment and
3 auxiliary structures.

4
5 **Q. WHAT SEISMOLOGICAL EVALUATION AND GEOTECHNICAL**
6 **WORK ARE REQUIRED AND HAVE BEEN PERFORMED, AND**
7 **WHAT ARE THE RESULTS?**

8 A. The seismic design requirements for proposed Units 2 and 3 are
9 based on current regulations and NRC Regulatory Guidance, specifically
10 Regulatory Guide 1.208, which require that a Probabilistic Seismic Hazard
11 Analysis (PSHA) be developed based on historical seismicity, expert
12 interpretations of all possible seismic sources (including source zones and
13 faults), consensus expert opinions and weighting on the likelihood of
14 ranges of earthquake magnitudes from each seismic source. The PSHA
15 process results in a Uniform Hazard Spectrum for the site which is then
16 converted via engineering procedures to define the site Ground Motion
17 Response Spectra (GMRS) for use as the seismic input motion for the new
18 plants.

19 All site field investigations were conducted in accordance with NRC
20 regulatory guidance, and specifically NRC Regulatory Guide 1.132, which
21 discusses the objectives of the subsurface investigation for the design of
22 foundations and associated critical structures. The subsurface field

1 investigation was performed primarily between April and August 2006.
2 Most of the investigation was conducted in the main plant area. The site
3 investigation included:

- 4 • 111 exploratory borings;
- 5 • 31 observation wells;
- 6 • 36 cone penetrometer tests (CPTs);
- 7 • 8 sets of borehole geophysical logging and 8 sets of suspension
8 primary shear (P-S) velocity logging; and
- 9 • 4 test pits.

10 Sections 2.5.4.2.3 and 2.5.4.2.4 of the FSAR contain more detailed
11 descriptions of the fieldwork and laboratory testing for the geotechnical
12 investigation of the site. For example, as more fully described in Section
13 2.5.4.2.3.1 of the FSAR, 111 borings were taken on the VCSNS site, with
14 88 of those borings focused on the power block areas, as reflected in the
15 figure below from the FSAR.

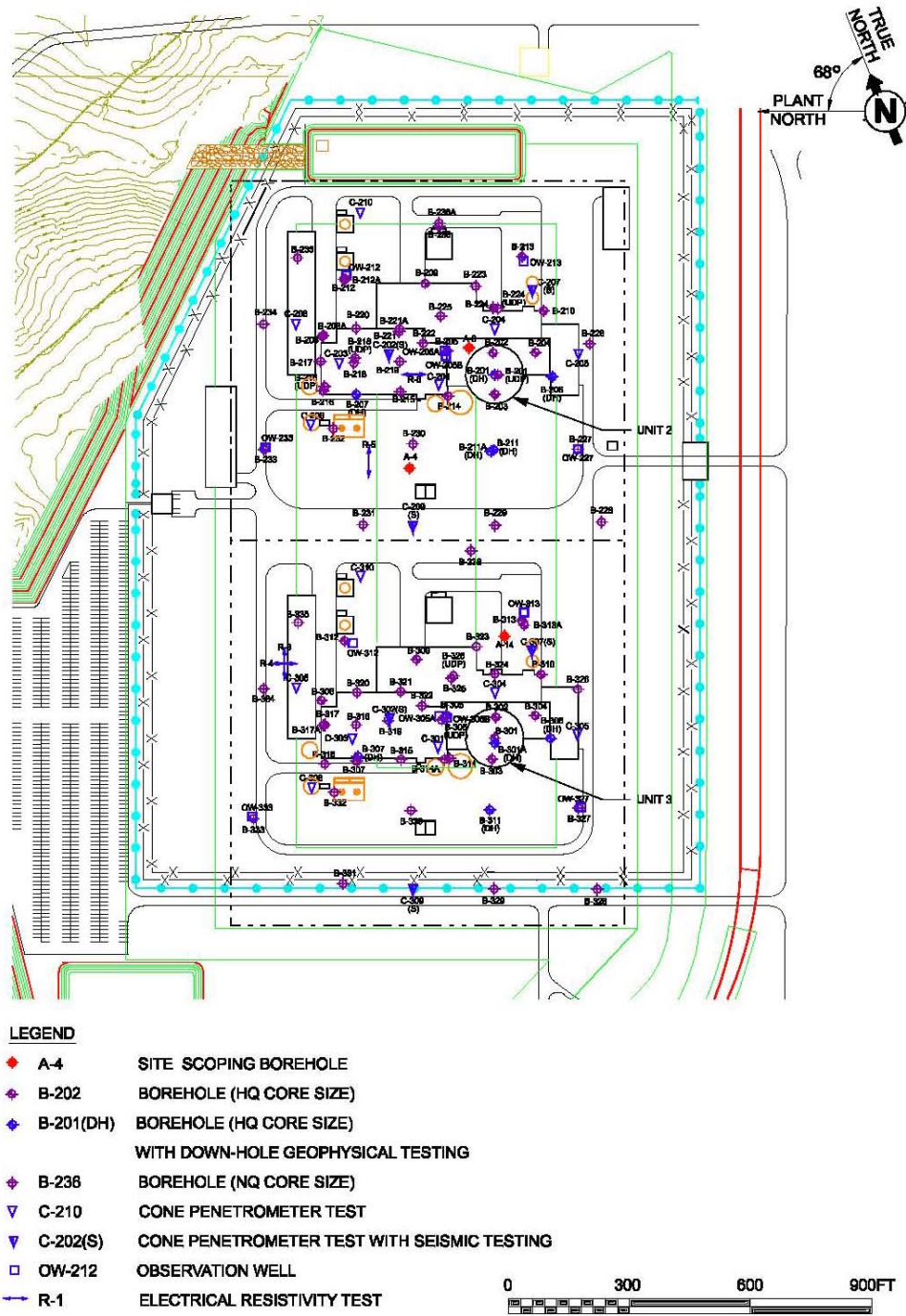


Figure 2.5.4-208. Boring Location Plan (Power Block)

1 The two deepest borings were taken at the center of the reactor locations for
2 Units 2 and 3 and are noted as B-201 and B-301. These borings
3 demonstrated the quality of bedrock for the unit sitings.
4

5 **Q. FROM A GEOLOGICAL PERSPECTIVE, WHAT MAKES THE**
6 **V.C. SUMMER NUCLEAR STATION SITE PARTICULARLY**
7 **SUITABLE FOR SITING THE PROPOSED NUCLEAR PLANTS?**

8 A. Due to the location, depth, and quality of the bedrock at the
9 proposed site, the VCSNS Site is particularly well-suited for siting and
10 design of the Westinghouse AP1000 plants. At the foundation level of the
11 nuclear island, the bedrock has a measured shear wave velocity of 9,200
12 feet per second (fps) and greater, which meets the definition of “rock” per
13 NRC regulatory guidance. The soundness and quality of the rock can be
14 determined by its shear wave velocity. The higher the value, the more
15 sound the rock. This value also exceeds the Westinghouse AP1000 design
16 input level of 8,000 fps to qualify as a rock site for its seismic design. The
17 depth of this quality of rock is also about 40 feet below the proposed
18 finished plant grade, which closely matches the Westinghouse AP1000
19 design embedment depth of 40 feet below plant grade. Details on the site
20 rock quality are described in FSAR Section 2.5.4.
21

1 **Q. WHAT RECORDS AND DATA OF SEISMOLOGICAL EVENTS**
2 **ASSIST YOU IN DEVELOPING AN EXPERT OPINION ON THE**
3 **SUITABILITY OF THE SITE?**

4 A. Sections 2.5.1 and 2.5.2 of the FSAR provide detailed descriptions
5 and discussions on local and regional site conditions, along with earthquake
6 potential from all viable seismic source zones and conclude that there are
7 no capable tectonic sources within a 25-mile radius of the VCSNS site.
8 The records and data utilized in investigating the site includes historical
9 earthquake data, scientific publications and studies, regulatory standards
10 and guidance letters, industry standards and guidance, and actual data
11 gathered at the site location through the monitoring and investigation
12 related to Unit 1 and the geological and geotechnical investigations that I
13 have already described for the specific locations of Units 2 and 3 at the
14 VCSNS Site.

15 All this data contributed to the PSHA process, which encompasses
16 all aspects of seismic occurrences and sources, and provides an accepted
17 methodology for predicting the maximum seismic hazard at a site.

18

19 **Q. ASSUMING THAT THE SITE WAS THE EPICENTER FOR AN**
20 **EARTHQUAKE OF THE SAME MAGNITUDE AND INTENSITY**
21 **AS THE LARGEST EARTHQUAKE ON RECORD IN THE SOUTH**
22 **CAROLINA SECTION OF THE PIEDMONT PROVINCE, WHAT**

1 **WOULD BE THE EFFECT OF THAT EARTHQUAKE ON THE**
2 **FACILITY?**

3 A. The largest earthquake on record in the South Carolina section of the
4 Piedmont province is the 1913 Union County earthquake (approximately
5 Magnitude 5.0 on the Richter Scale). This Union County earthquake has
6 never been tied to an exact fault location. Based on consensus of expert
7 opinion, a similar magnitude earthquake could occur anywhere in the
8 Piedmont province. I compared the input motion from this magnitude
9 earthquake at the VCSNS Site to the seismic design input level of Unit 2
10 and 3 and have concluded that the resulting motion from this earthquake
11 would be significantly less. In other words, such an earthquake would not
12 exceed the seismic design requirements of Units 2 and 3.

13 No other major historical earthquake has been recorded in the South
14 Carolina section of the Piedmont province. The consensus of expert
15 opinion is that historical large earthquakes, which cannot be directly related
16 to a known fault, are generally believed to only be capable of recurrence in
17 either the historical location or within a common geologic province.

18

19 **Q. WHAT CRITERIA AND GUIDELINES DO YOU FOLLOW IN**
20 **ASSESSING THE SAFETY OF THE SITE RELATED TO SEISMIC**
21 **EVENTS?**

1 A. The criteria and guidance for evaluating geological, geotechnical,
2 and seismological evaluations at a site are well defined in the NRC
3 regulations and regulatory guidance. These regulations, 10 C.F.R. 50 and
4 10 C.F.R. 100, provide requirements for seismic design, geologic and siting
5 criteria, and earthquake engineering criteria. Regulatory guides are
6 processes and recommendations which are acceptable to the NRC for
7 meeting the intent of the regulations. SCE&G has carefully followed the
8 regulatory standards and guidance in evaluating the VCSNS site and
9 performing the requisite geotechnical investigations and analyses.

10

11 **Q. IN YOUR EXPERT OPINION, DOES THE V.C. SUMMER**
12 **NUCLEAR STATION SITE OFFER A GEOLOGICALLY AND**
13 **SEISMICLY SAFE SITE FOR THE CONSTRUCTION AND**
14 **OPERATION OF UNITS 2 AND 3?**

15 A. Yes. From a geological and geotechnical perspective, the VCSNS
16 site provides an excellent foundation medium for construction of the new
17 plants. The rock quality at this site meets the design requirements of the
18 Westinghouse AP1000 plant and is an excellent site upon which to locate
19 Units 2 and 3.

20 There are no sites in the southeastern U.S. that are exempt from
21 some level of earthquake hazard; however, the level of seismic design
22 inherent in these plants meets and in fact exceeds the earthquake potential

1 at this site. In summary, from a geological, geotechnical, and seismological
2 standpoint, the site at VCSNS provides an excellent and stable foundation
3 on which to construct Units 2 and 3 and allow for safe and reliable plant
4 operation.

5

6 **Q. DOES THIS CONCLUDE YOUR TESTIMONY?**

7 A. Yes.